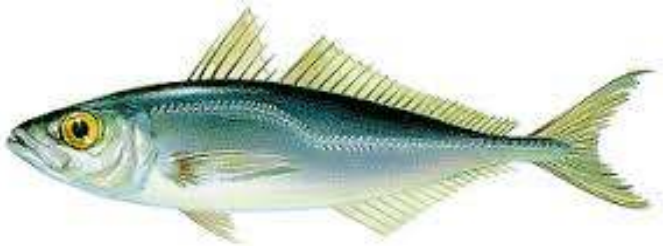
Southern horse mackerel, *Trachurus trachurus* Life-history: Reproduction



Ana Costa, Begoña Villamor, Carmo Silva, Cristina Nunes, Daniel Pinto, José Ramón Perez, Mónica Inácio, Paula Abreu

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DATA

ICES Division IXa CS

- ✓ DCF - 1992-2015
- ✓ Egg Production Methods
  - ✓ DEPM - 1992, 2002, 2006 (NeoMAv), 2007, 2010, 2013
  - ✓ AEPM - 1995, 1998, 2001, 2004
  - ✓ IBTS - 2007
- ✓ Annual cycle - Jan. 2014 - Jan. 2015

ICES Divisions VIIIc and IXa N

- ✓ DCF - 2010-2015

RESULTS

- ✓ Sex ratio
- ✓ % maturity stages
- ✓ GSI
- ✓ K
- ✓ L_{50} (macro and micro)
- ✓ Fecundity

- ✓ Comparison of the values of GSI and K from Divisions VIIIc, IXa N and IXa CS

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✓ DCF - 1992-2015

YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1992	18	20		88	103	78	45	34	102	92	53	59	692
1993	68	92	42	72	143	142	71	78	86	88	111		993
1994	58	35	85	65	62	52	49	67	61	74	79	42	729
1995	33	187	69	93	71	182	173	52	27	47	73	33	1040
1996	113	59	79	134	188	31	63	146	172	81	97	35	1198
1997	237	273	150	334	365	314	223	89	67	128	137	97	2414
1998	247	291	324	150	189	145	233	210	139	277	186	161	2552
1999	201	118	168	186	207	183	225	211	244	199	184	107	2233
2000	273	260	190	199	209	224	214	152	210	165	224	152	2472
2001	273	240	223	282	261	367	188	191	232	268	245	139	2909
2002	314	298	231	327	436	304	248	214	142	239	286	197	3236
2003	108	152	257	245	212	269	148	202	209	268	179	71	2320
2004	207	251	246	274	220	322	248	97	202	160	307	11	2545
2005	135	192	204	214	312	400	308	182	364	324	298		2933
2006	137	212	413	366	145	258	318	246	223	282	156		2756
2007	129	199	233	208	323	311	213	258	180	277	226		2557
2008	176	160	113	214	427	287	295	164	216	196	184		2432
2009	1	258	159	197	285	254	277	196	231	246	211	119	2434
2010	260	360	427	240	353	294	249	260	182	247	218		3090
2011	248	199	144	181	181	249	222	204	244	221	265	229	2587
2012	290	184	132	146	190	320	312	92	112	180	312	271	2541
2013	305	1249	278	148	278	309	293	304	199	289	281	282	4215
2014	262	223	278	321	194	222	216	187	182	289	216	271	2861
2015	243	304	300	285	249	269	220	165	274	263	324	232	3128
Total	4336	5816	4745	4969	5603	5786	5051	4001	4300	4900	4852	2508	56867

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DATA

ICES Division IXa CS

✓ Annual cycle - Jan. 2014 - Jan. 2015

Length	2014												2015	Total
	1	2	3	4	5	6	7	8	9	10	11	12	1	
20									1					1
21									3					3
22									10				10	20
23									10				10	20
24							1		10				10	21
25								1	10				10	21
26									8				6	14
27	2		1				1	6	1	2			4	17
28			5	1			1	3	1	3			2	16
29			8	4		1	10	5		10		1		39
30			10	4		5	10	10		10	3	6		58
31	3		10	10		10	10	10		10	10	8		81
32	7		10	10	8	10	10	10		10	9	10		94
33	10		10	9	10	10	10	10		10	10	10		99
34	10		5	10	10	10	6	9		7	6	9		82
35	10		2	9	10	8	2	1		2	1	9		54
36	7			4	10	9				2	1			33
37	9			4	5						2			20
38	3				2	1	1							7
Total	61	0	61	65	55	64	62	65	54	66	42	53	52	700

ICES Divisions VIIIc and IXa N

✓ DCF - 2010-2015

VIIIc

Year	1	2	3	4	5	6	7	8	9	10	11	12	Total
2010							4		3	12		2	21
2011	85	25	115		122	40		42	75	48		52	604
2012	82		41		44	81	40	80	40	75	78		561
2013		41	80		80	45	80	42		40	40	55	503
2014	45	40		40	80	80	39	40	40	42	78		524
2015	43	40	41	65	70	40	41		21			84	445
Total	255	146	277	105	396	286	204	204	179	217	196	193	2658

IXa N

Year	1	2	3	4	5	6	7	8	9	10	11	12	Total
2010												72	72
2011	47		54			498		656	360		440	936	2991
2012	40	80			225		287			890			1522
2013	50	100			215	240	315	328		430		552	2230
2014	43	34		200	200			824		920		504	2725
2015	61		189		275	246	560	400		940			2671
Total	241	214	243	200	915	984	1162	2208	360	3180	440	2064	12211

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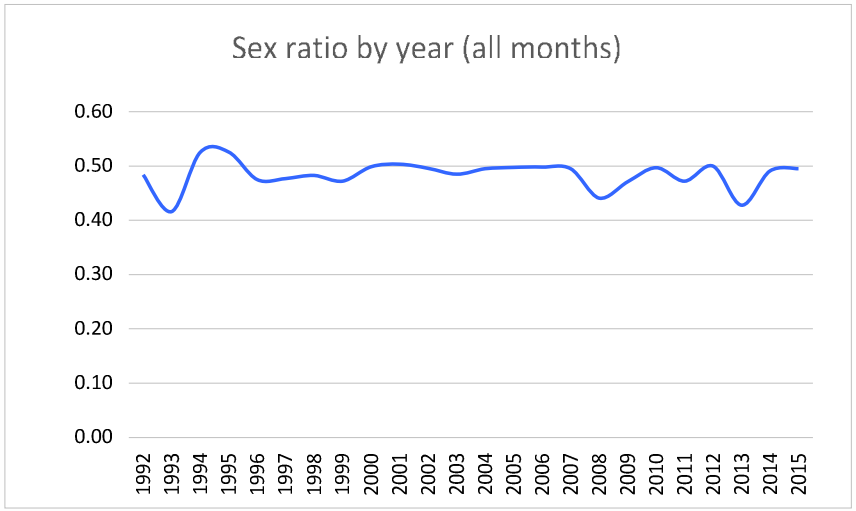
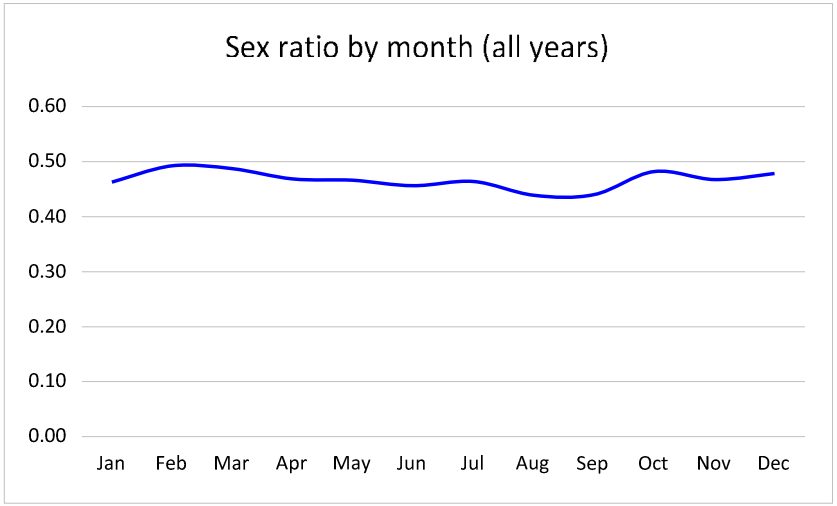
Spawning season

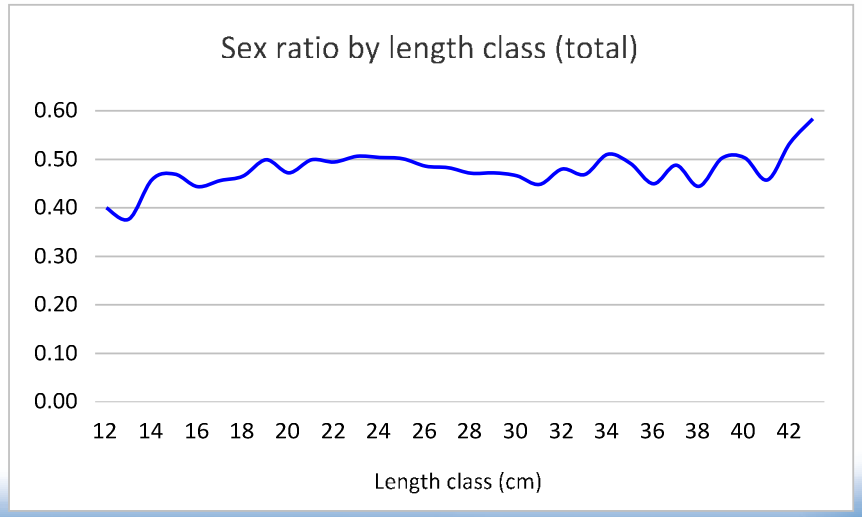
...

Sex ratio - 1992/2015

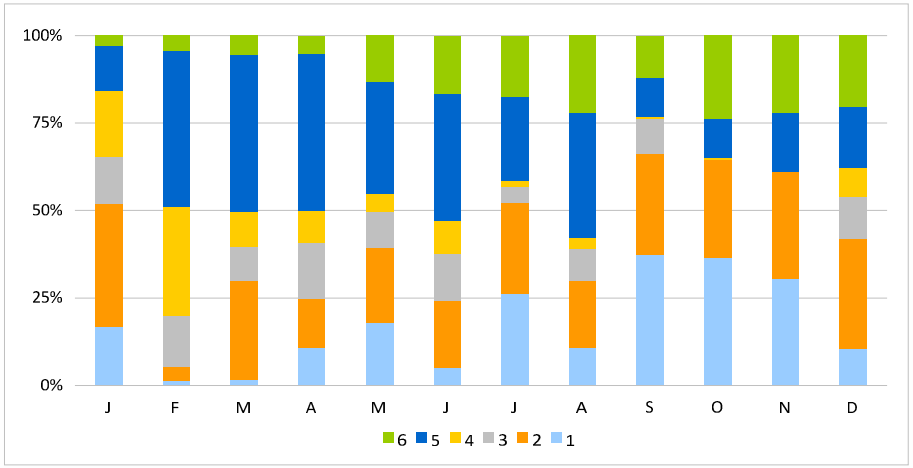




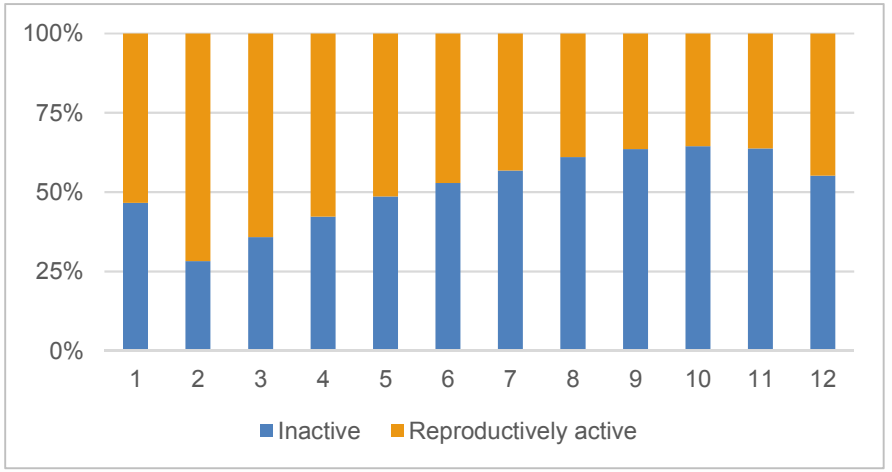
$$Sex\,ratio = \frac{N^{o}\ females}{N^{o}\ females + N^{o}\ males}$$



Maturity stages - 1992/2015



macro



IMMATURE
- 1 - immature
- 2 - early developing

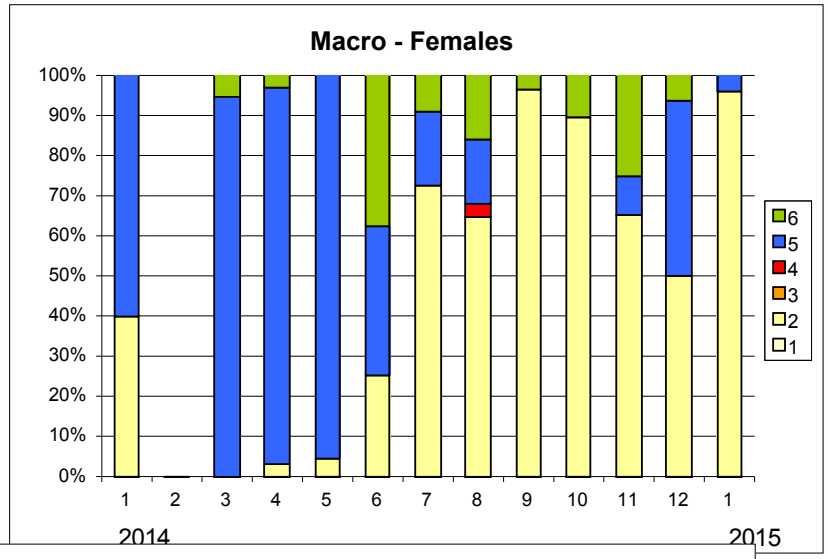
MATURE
- 3 - late developing
- 4 - spawning
- 5 - partly spent
- 6 - regressing/regenerating

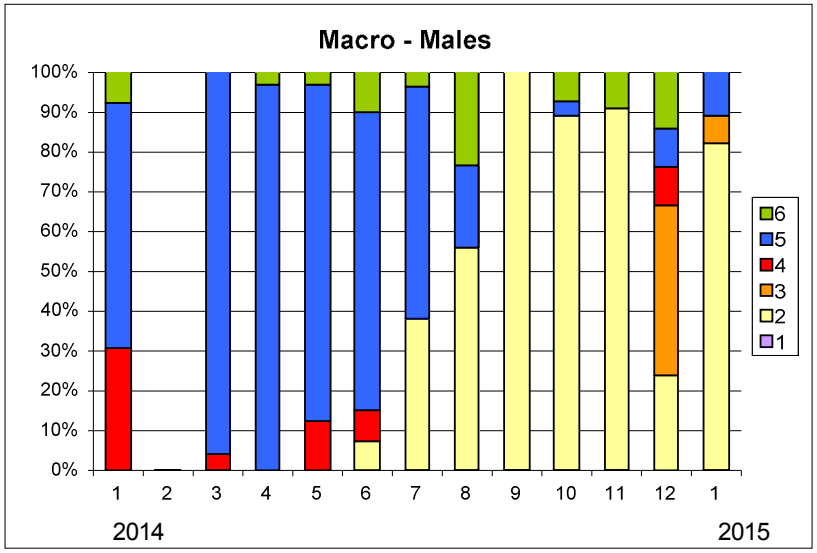
INACTIVE

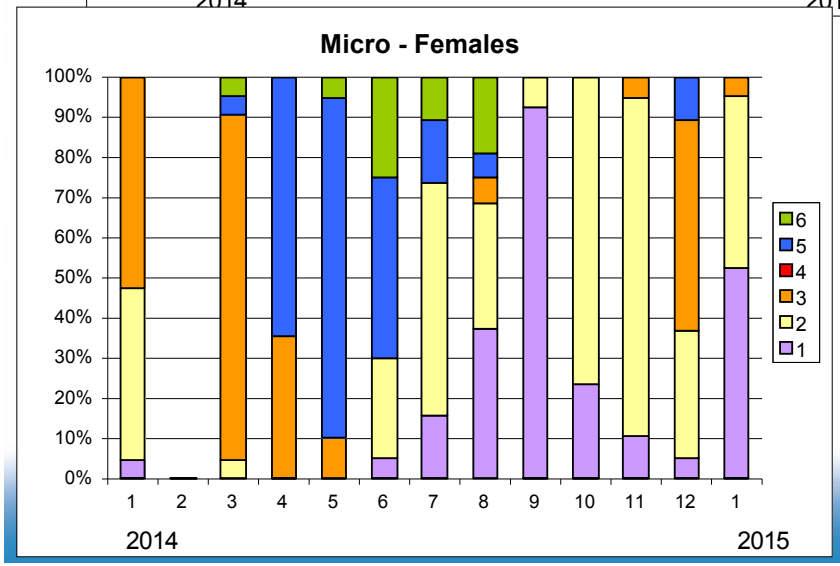
REPRODUCTIVELY ACTIVE

INACTIVE

Maturity stages - Annual cycle (2014)







IMMATURE
- 1 - immature
- 2 - early developing
- 3 - late developing
- 4 - spawning
- 5 - partly spent
- 6 - regressing/regenerating

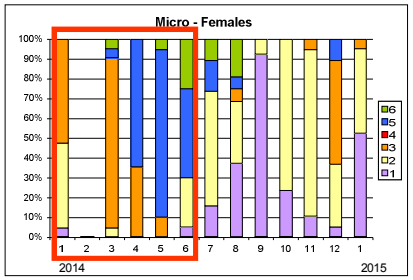
MATURE

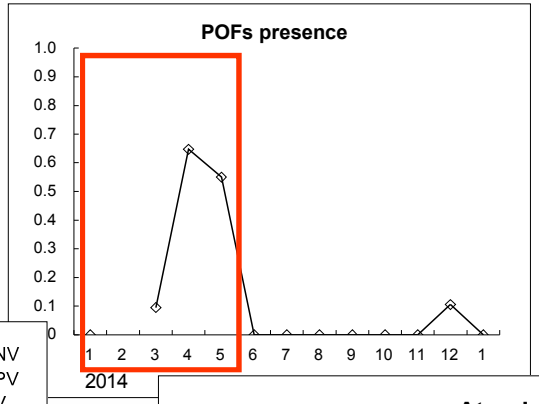
INACTIVE

REPRODUCT. ACTIVE

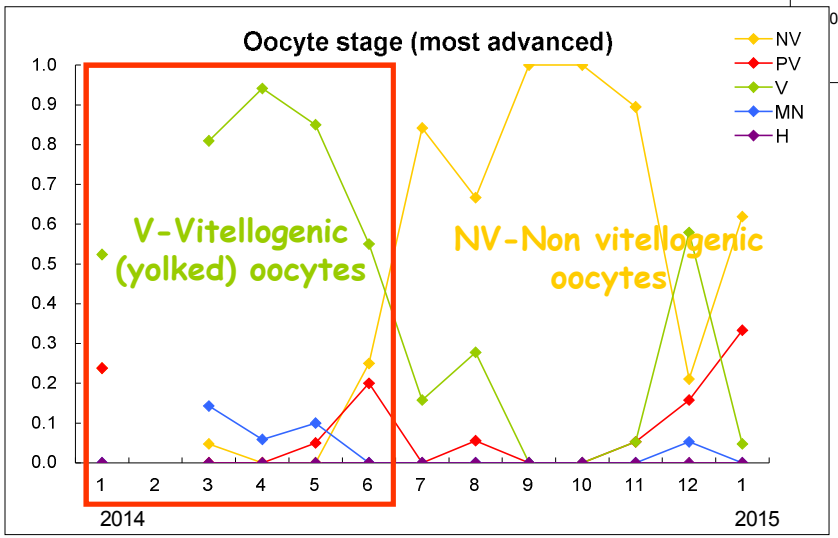
INACTIVE

Reproductive activity (♀) - Annual cycle (2014)

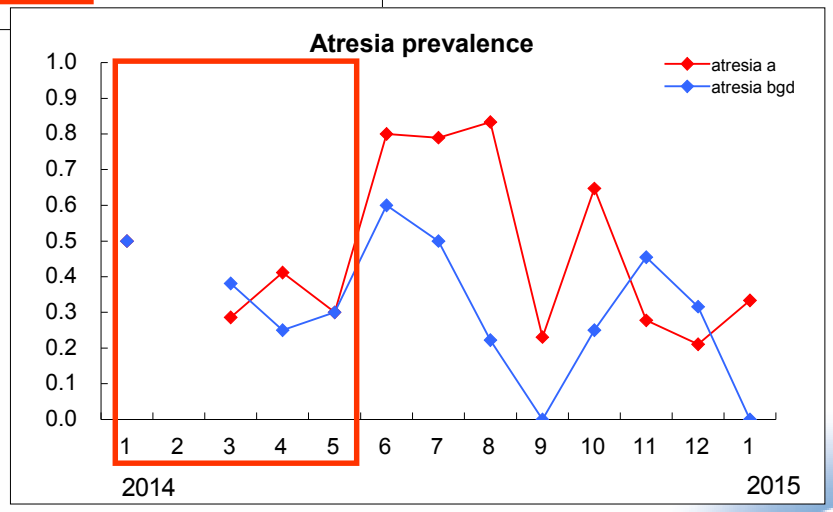




Proportion of females with post-ovulatory follicles (POFs) in the ovary



The most advanced oocyte stage in the ovary of the females sampled



Proportion of females with atresia in the ovary

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Macroscopic vs microscopic identification

Percentage of correspondence with macroscopic maturity assignment

Macrosc. matur.	Microsc. matur. 1	2	3	4	5	6
1	67	30.3	0.5		0.5	1.6
2	9.2	80.3	1.2		5.8	3.5
3	0.8	3.7	28.3	4.9	60.5	1.8
4			0.6	97.8	1.6	
5	0.8	4.2	13.6	4.4	74.5	2.5
6		12.9	1.4		60.7	25

(Costa, 2009)

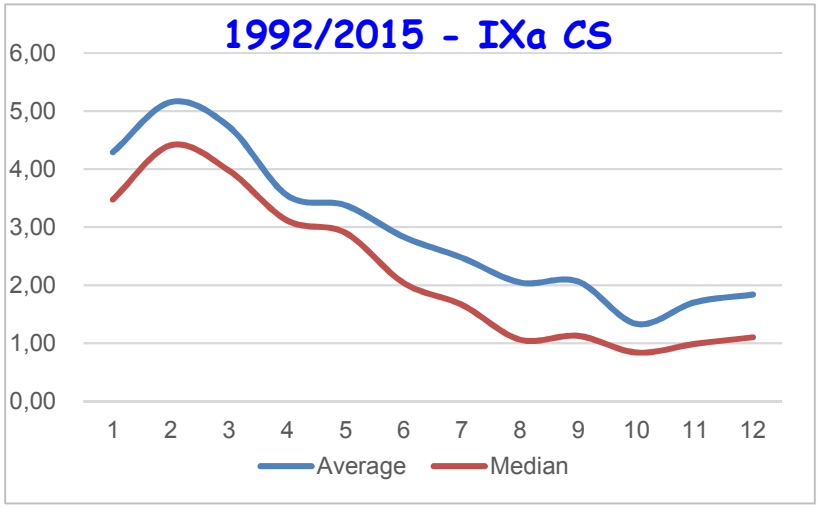
DCF and AEPM/DEPM/IBTS surveys data (1992-2007) n = 4432

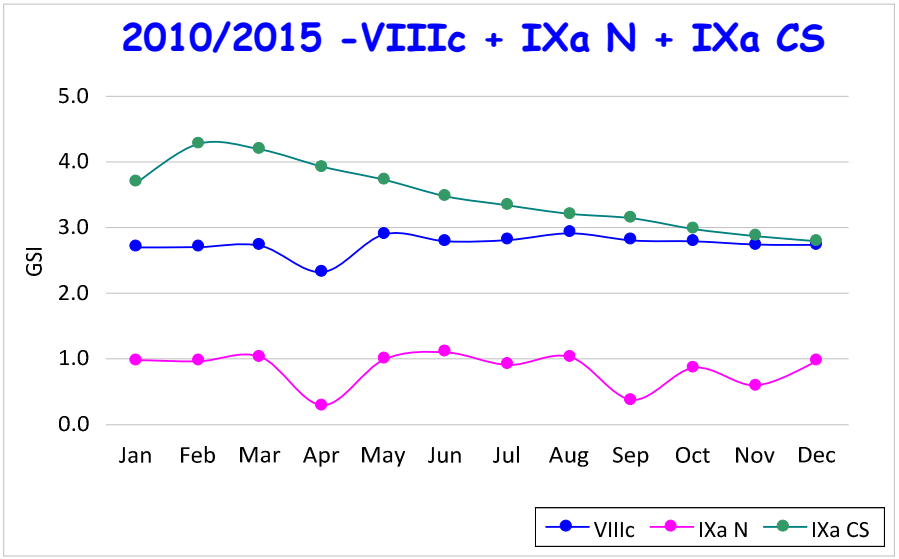
Annual cycle (Jan 2014 - Jan 2015) n = 223

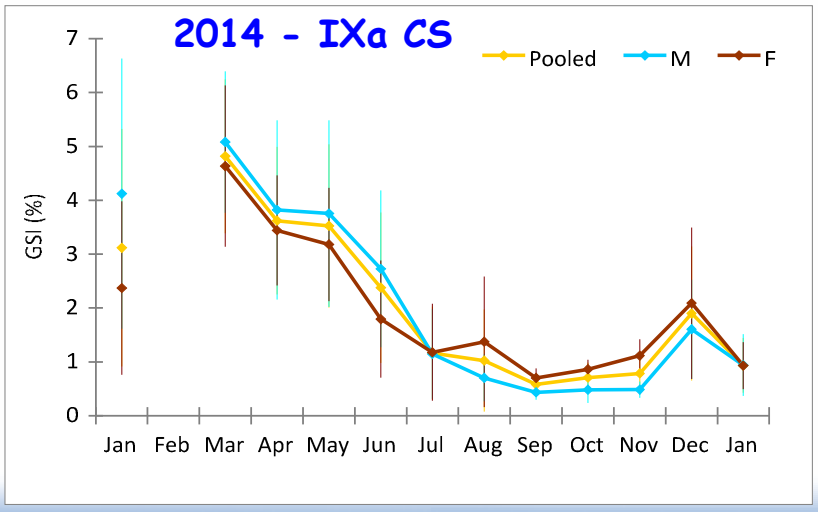
matur macro	matur_micro 1	2	3	4	5	6	Total
1	**0.0**						0
2	**100.0**	**86.8**				**16.7**	109
3							0
4						**8.3**	1
5		**3.9**	**96.0**		**97.7**	**16.7**	96
6		**9.2**	**4.0**		**2.3**	**58.3**	17
Total	41	76	50	0	44	12	**223**

Costa, A. M. 2009. Macroscopic vs. microscopic identification of the maturity stages of female horse mackerel. – *ICES Journal of Marine Science*, 66: 509-516.

Gonado-somatic index (GSI)







$$GSI = \frac{Gonad\ weight * 100}{Fish\ gutted\ weight}$$

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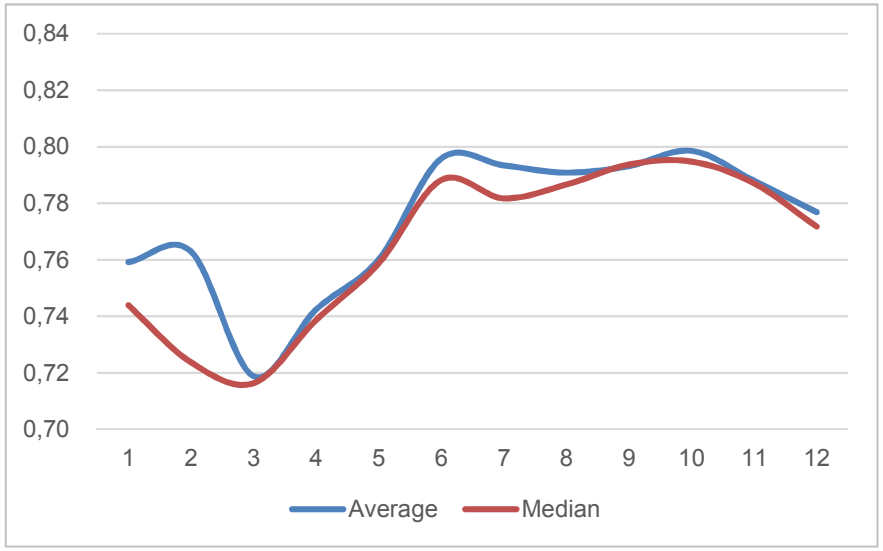
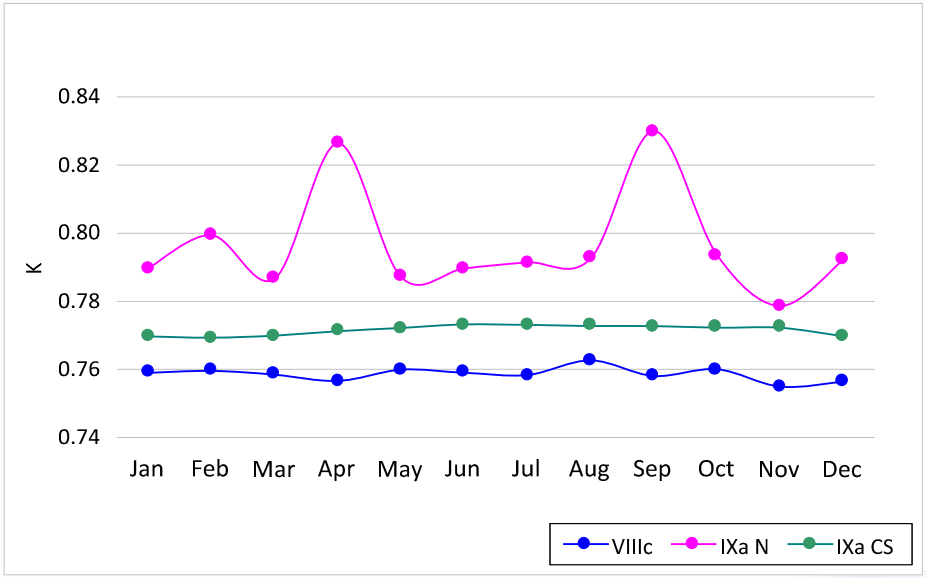
Fulton's condition factor (K)

1992/2015 - IXa CS



$$K = \frac{Fish\ gutted\ weight}{(Fish\ total\ length)^3}$$

2010/2015 -VIIIc + IXa N + IXa CS



Maturity ...

DATA

ICES Division IXa CS

- ✓ Egg Production Methods

macro

year	month 1	2	3	total
2002	434			434
2004	217	166	764	1147
2006		1341		1341
2007		618	759	1377
2010	114	1075	365	1554
2013		182		182
total	765	3382	1888	6035

micro

year	month 1	2	3	total
2002	115			115
2004	74	48	236	358
2006		1002		1002
2007		592	686	1278
2010	36	555	219	810
2013		422		422
total	225	2619	1141	3985

Year	Length 15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35+	Total
2002	1		3	1	3	7	12	19	19	27	14	8				1						115
2004				4	6	33	23	33	38	40	54	36	27	23	19	11	5	4	1		1	358
2006	7	5	14	29	51	60	85	97	96	106	131	150	99	51	20	1						1002
2007	2	37	63	202	253	167	85	39	35	60	66	93	67	45	33	18	7	3		1	2	1278
2010			1		2	14	31	67	89	109	80	67	50	28	31	34	55	56	61	22	13	810
2013					1	2	3	23	23	13	9	22	45	41	52	54	62	31	22	15	4	422
Total	10	42	81	236	316	283	239	278	300	355	354	376	288	188	155	119	129	94	84	38	20	3985

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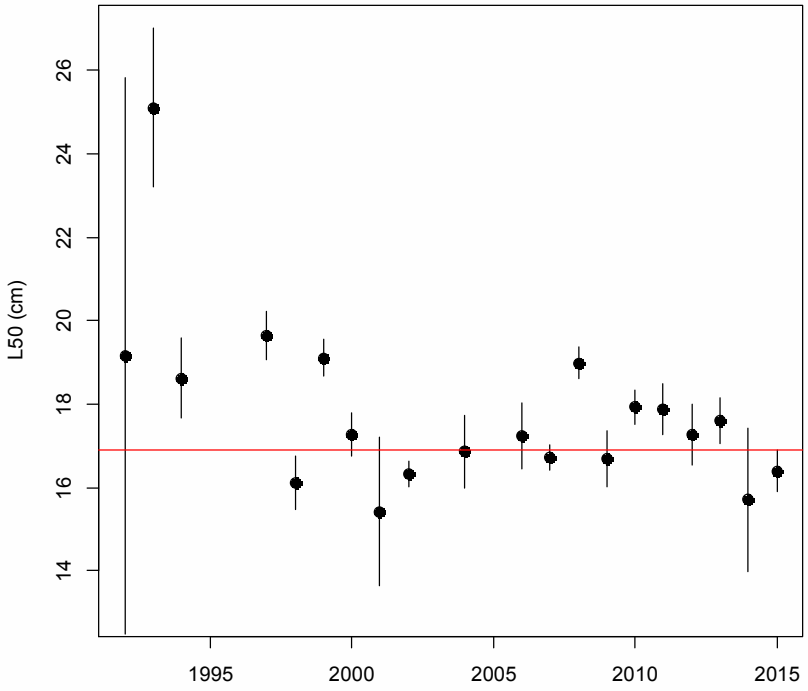
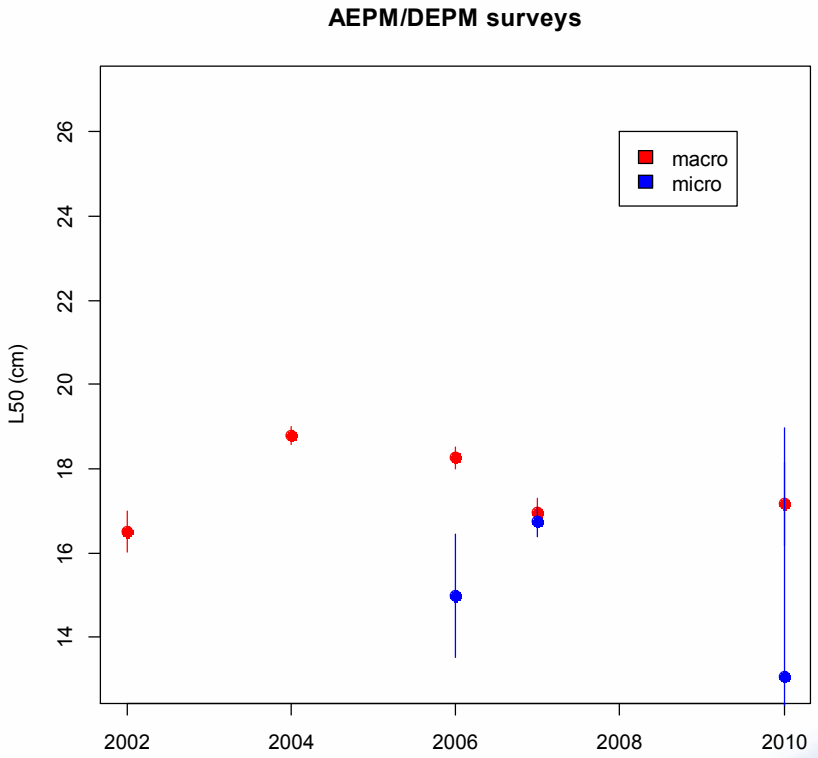
Maturity at length

- ✓ Females
- ✓ Within main spawning season



Not possible to estimate for 1995, 1996, 2003 and 2005

DCF data (macro)

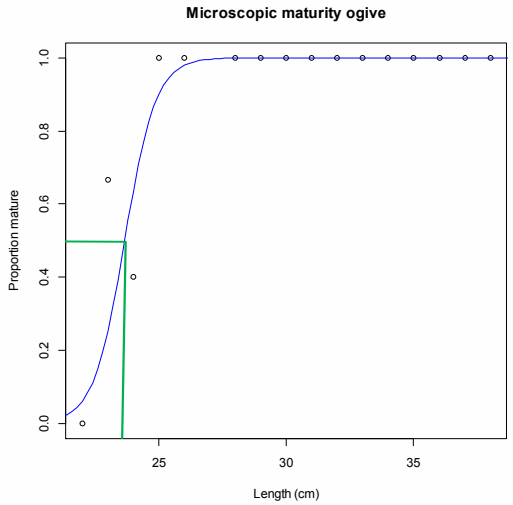


AEPM/DEPM

Not possible to estimate for 2013

Maturity at length

- ✓ **Females**
- ✓ **Within main spawning season**



Annual cycle (2014)

Macro: not possible

Micro: L_{50} = 23.67 (se = 0.39)

?

!! ovary wall width

Maturity at age

Age data:

- ✓ DCF: available
- ✓ AEPM/DEPM surveys: not available (except for 2006)

⇩

Methodology:

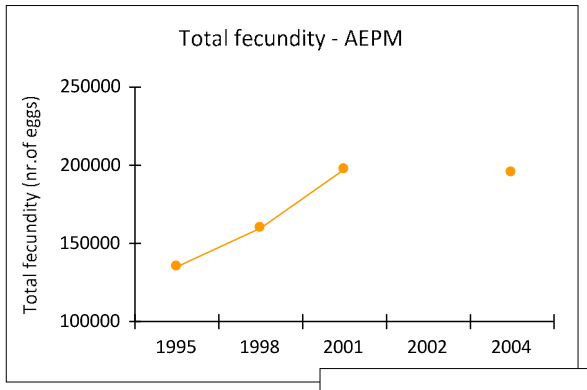
If AEPM/DEPM surveys used (PROS: microscopical information available, during main spawning season):

- ✓ application of ALK from DCF samples (1T)
- ✓ in egg production surveys, samples collected randomly - assume they are representative of the population

Fecundity...

Fecundity

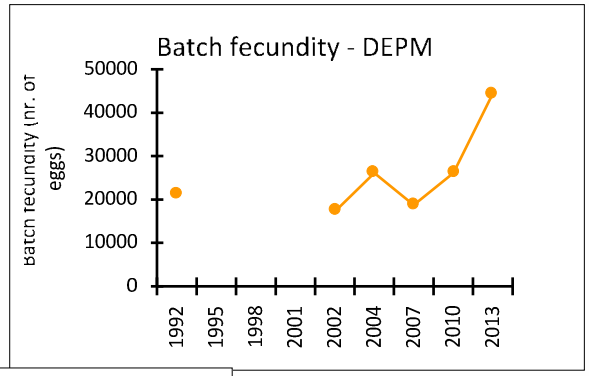
AEPM



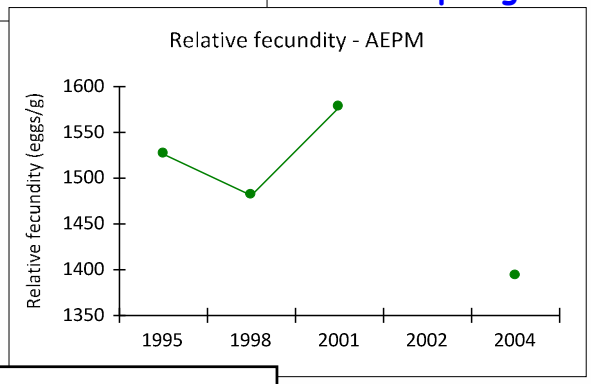
Total fecundity = number of vitellogenic oocytes in the ovary (*)

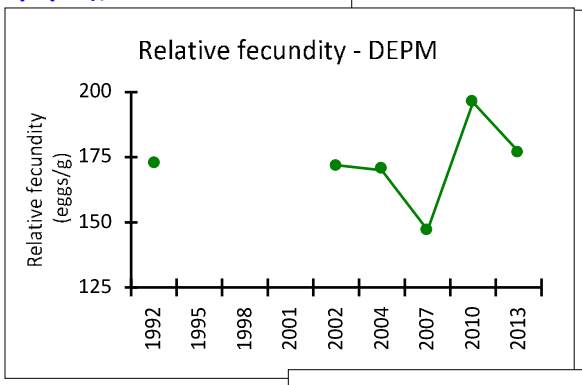
DEPM

Batch fecundity = number of eggs spawned in a single spawning event (**)



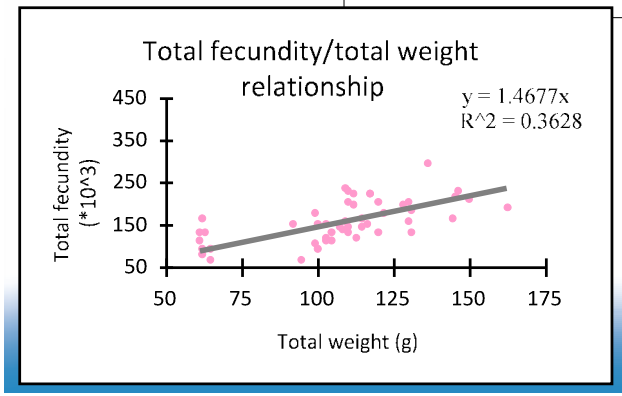
per gramme of female:





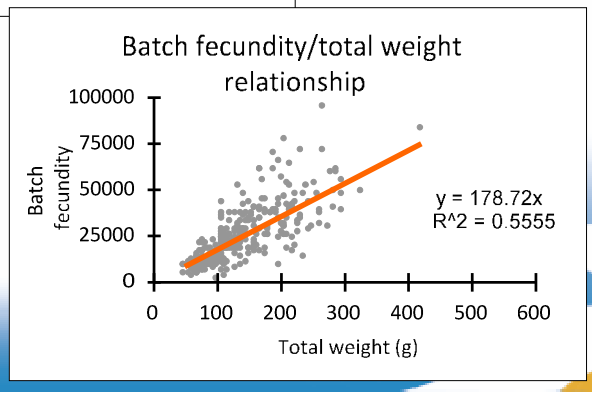
(*) = potential annual fecundity at the beginning of spawning season in determinate spawners

(**) = different from the potential annual fecundity in indeterminate spawners



relationship between fecundity and female total weight:

!! change in stock boundaries and in egg production method in 2007



"Take-home messages" ...

- HOM spawning season not fully clear: existence of a main spawning season (Dec-Jan to May-Jun?), but fish are observed to be reproductively active almost whole year (some population asynchronism?)

  Needs further clarification?

- Problems in the macroscopical assignment of maturity stages - consequences in the delimitation of the spawning season? in the distinction between immature/mature/resting individuals?

  Importance of using microscopical data

- Maturity at length showing some inter-annual variability, but...

  Needs checking the conseguence on the maturity at age

  Decide on which data to use (requisites: micro, during spawning season): DEPM surveys?

  Improve sampling (especially for the smaller individuals)

- Inter-annual changes in HOM relative (batch and total) fecundity, suggesting possible variations in HOM reproductive potential BUT time series still short to infer

  Considering HOM reproductive strategy (indeterminate batch spawner), still difficult to estimate reproductive potential

THANK YOU

Acknowledgements:
EU DCF
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All institute colleagues and RVs crews who helped collecting the biological data
All colleagues from the histological lab who processed the gonad samples

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